(*From the Author.*)

SUPPLEMENT

TO

The Fifth Edition

OF A

MANUAL OF ELEMENTARY GEOLOGY.

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CONTENTS.

LYELL'S ELEMENTARY GEOLOGY.

SUPPLEMENT TO THE FIFTH EDITION.

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BRITISH PLIOCENE STRATA.

British Pliocene Strata—Proofs from fossil shells of a gradual refrigeration of climate in England, at the successive periods of the Coralline, the Red, and the Norwich Crag—Searles Wood's Monograph on the Crag Mollusca. The Crag Mastodon, a Pliocene species—Different assemblages of fossil Mammalia in the freshwater and drift deposits of the Valley of the Thames—Fossil Musk-ox in the drift near London and near Berlin.

SINCE the appearance of the fifth edition of this work, Mr. Searles Wood has brought to a conclusion his important Monograph on the Crag and Upper Tertiary shells of Britain.* The results of his conscientious examination of so many hundred species of testacea, in so far as they bear on Geology, will be found to agree with the classification adopted in the text (pp. 155—168., &c.), especially as relates to the position of the several divisions of the Crag in the great European series of formations. But we may also deduce from the same Monograph clear evidence of a gradual refrigeration of climate, which went on in the area of England from the time of the Crag older to that of the most modern Pliocene strata. No analysis of this excellent treatise has been drawn up for us by the author himself: we have therefore inserted the following tables, to point out many general conclusions to which the conchological data seem to lead. In drawing them up I have had the able assistance of Mr. S. P. Woodward, the well-known author of the "Manual of the Mollusca, Recent and Fossil."†

Number of known Species of Marine Testacea in the three English Pliocene Deposits, called the Norwich, the Red, and the Coralline Crags.

Brachiopoda - - - -	6
Conchifera - - - -	206
Gasteropoda - - - -	230
Total - - - -	442

* Paleontological Society, 1848 to 1856.
† London: 1853–6.

Distribution of the above Marine Testacea.

Number of Species.		Species common to the	
Norwich Crag	81	Norwich and Red Crag	33
Red Crag	225	Norwich and Coralline	4
Coralline Crag	327	Red and Coralline	116
		Norwich, Red, and Coralline	19

Proportion of Recent to Extinct Species.

	Recent.	Extinct.	Per-centage of Recent.
Norwich Crag	69	12	85
Red Crag	130	95	57
Coralline Crag	168	159	51

Recent Species not living now in British Seas.

	Northern Species.	Southern.
Norwich Crag	12	0
Red Crag	8	16
Coralline Crag	2	27

In the above list I have not included the shells of the glacial beds of the Clyde and of several other British deposits of newer origin than the Norwich Crag, in which nearly all — perhaps all — the species are recent, although such fossils are described by Mr. Wood, or enumerated in his Appendix. The land and freshwater shells, 32 in number, have also been purposely omitted, as well as three species of London Clay shells, suspected by Mr. Wood himself to be spurious.

By far the greater number of the recent marine species included in these tables are still inhabitants of the British seas; but even these differ considerably in their relative abundance, some of the commonest of the Crag shells being now extremely scarce; as, for example, *Buccinum Dalei,* and others rarely met with in a fossil state, being now very common, as *Murex erinaceus* and *Cardium echinatum.*

The last table throws light on a marked alteration in the climate of the three successive periods. It will be seen that in the Coralline Crag, there are 27 Southern shells, including 26 Mediterranean, and one West Indian species (*Erato Maugeræ*). Of these only 13 occur in the Red Crag, associated with 3 new Southern species, while the whole of them disappear from the Norwich beds. On the other hand the Coralline Crag contains only 2 Arctic shells, *Admete viridula* and *Limopsis pygmæa;* whereas the Red Crag contains, as stated in the table, 8 Northern species, all of which recur in the Norwich Crag, with the addition of 4 others, also inhabitants of the Arctic regions; so that there is good evidence of a continual refrigeration of climate during the Pliocene period in Britain. The presence of these Northern shells cannot be explained away by supposing that they were inhabitants of the deep parts of the Sea; for some of them, such as *Tellina calcarea* and *Astarte borealis,* occur plentifully, and sometimes

with the valves united by their ligament, in company with other littoral shells, such as *Mya arenaria* and *Littorina rudis*, and evidently not thrown up from deep water. Yet the northern character of the Norwich Crag is not fully shown by simply saying that it contains 12 Northern species now no longer found in British seas, since several boreal shells which still linger in the Scottish deeps, do not abound there as they did in the latter days of the Crag Period. It is the predominance of certain genera and species which satisfies the mind of a conchologist as to the Arctic character of the Norwich Crag. In like manner, it is the presence of such genera as *Pyrula, Columbella, Terebra, Cassidaria, Pholadomya, Lingula, Discina*, and others, which give a southern aspect to the Coralline Crag shells.

In conclusion, it may be observed that the cold which had gone on increasing from the time of the Coralline to that of the Norwich Crag continued, though not perhaps without some oscillations of temperature, to become more and more severe after the accumulation of the latter, until it reached its maximum in what has been called the Glacial epoch. The marine fauna of this last period contains, both in Ireland and Scotland, recent species of mollusca now living in Greenland and other seas far north of the areas where we find their remains in a fossil state.

It is not in reference to the two older formations above alluded to, but when we attempt to classify the lacustrine and fluviatile deposits, some contemporaneous with the marine Norwich Crag and others posterior to it, that we encounter in the East and South of England the greatest difficulty. When treating of the Newer Pliocene and drift formation in the Valley of the Thames, I have acknowledged the perplexity in which this subject is still involved, and have hinted at the causes of it (chap. xiii. pp. 153, 154.). Every year, however, removes some of this ambiguity; for the true relative position of distinct sets of superficial strata becomes more clearly understood, and the specific characters of the fossil mammalia and shells better ascertained. In the first place, the occurrence in the Norwich Crag of many marine shells of Northern species, as before described in company with land and freshwater shells, and some mammalia of a more Southern character, may possibly be explained by supposing the sea of the Norwich Crag to have been open towards the Pole, with islands interspersed, while the land of the same period was continuous far to the South. In that direction a Continent may have existed, from which rivers flowed northwards, in whose waters the hippopotamus and such shells as the *Cyrena consobrina* flourished.

The Mastodon found in the Red and Norwich Crag (p. 156., and fig. 135. p. 166.) was till lately regarded as a Miocene or Falunian species; and under this persuasion calling it *M. angustidens*, on the authority of Professor Owen, I suggested that its remains might have been washed out of older strata into the Crag, just as we sometimes observe London Clay and Chalk fossils occasionally introduced into the same deposit. Many teeth of this Mastodon, together

with numerous ear-bones of whales, have recently been found at Felixstow, in what is called "the detrital bed," so rich in phosphate of lime used in agriculture. That accumulation of drifted materials lies at the base of the Red Crag, and it has been supposed that the imbedded mammalian fossils were derived from the destruction of an older set of strata. But in regard to the Mastodon above mentioned, Dr. Falconer, who has devoted fifteen years to the study of the fossil and recent Proboscideans, assures me that the fossil is a well-known Pliocene animal, first observed in Auvergne by MM. Croizet and Jobert, and called by them *Mastodon arvernensis.* Cuvier did not adopt this name, for he had seen but a few specimens from Auvergne, and he confounded it with *M. angustidens.* The entire skeleton of both these Mastodons having now been obtained, they are found to be referable to two distinct sub-genera. The Crag fossil belongs to the *Tetralophodon* of Falconer, a sub-genus of which five species are known, so called because there are four ridges in the antepenultimate true molar as well as in the two teeth which are placed immediately before it in both jaws. The *Mastodon angustidens,* on the other hand, belongs, with six other species, to the section called *Trilophodon,* in which the corresponding teeth have each three ridges. This Mastodon, according to MM. Lartet and Falconer, is characteristic of the Faluns and of the Molasse at Sansan at the foot of the Pyrenees, and of several other Miocene localities.*

The *Mastodon arvernensis* is, according to Dr. Falconer, the only one yet found in England. It abounds with the *Hippopotamus major* in the Pliocene strata of the Val d'Arno, as well as in strata of the same age in Piedmont and at Montpellier. It may be considered, therefore, as a characteristic Pliocene species; and this view is in accordance with the fact that its remains are best preserved in freshwater strata associated and coeval with the Norwich Crag. But we have no evidence of its surviving in England till the still more modern epoch of those fluviatile deposits in the valley of the Thames in which the *Hippopotamus major* and a species of monkey, *Macacus pliocenus,* have been detected. These freshwater strata are alluded to in the text (p. 154.), as occurring at Grays in Essex, 21 miles below London, and at Ilford, Erith, and other places bordering the Thames. They consist of sand, gravel, and loam, from 60 to 100 feet thick, and often form a terrace on each side of the valley, rising to a much higher level than a vast bed of more modern gravel, to which allusion will presently be made. At Grays, the *Cyrena consobrina* of the Nile already mentioned, a shell common to the Norwich Crag, together with several other shells no longer inhabitants of Great Britain, and some of them unknown in any part of the globe, occur, mingled with a vast majority of English species of land and freshwater mollusca. The *Cyrena,* which I supposed till

* Professor Owen has given (Quart. Geol. Jour., Feb. 1856, p. 223.), as a synonym of the Crag Mastodon, the name of *M. longirostris,* Kaup, a fossil of the Miocene sands of Eppelsheim, referred by Falconer to the sub-genus *Tetralophodon.*

lately to be a genus unknown in Europe (p. 154.), is, as I learn from Mr. Woodward, a living Sicilian shell, called by some naturalists *C. panormitana*. With these fossils, and with the *Hippopotamus* and monkey above alluded to, the remains of *Rhinoceros leptorhinus* are found ; while the accompanying elephant is not the Mammoth, as formerly imagined, but, according to Dr. Falconer, *Elephas antiquus*, and sometimes *E. priscus*.

It is still a matter of discussion whether the submergence of a great part of the South East of England beneath the sea of the glacial epoch, during which the Northern erratics of Norfolk and Suffolk, and of Highgate Hill, near London, were drifted southwards by ice, took place before or after the origin of these deposits at Grays, Ilford, and other places on the banks of the Thames; but it is quite clear that after those fluviatile beds were formed, a great sheet of ochreous gravel was spread out over the lower levels of the same valley, and in it we find buried the remains of Arctic quadrupeds. This ochreous gravel extends from East to West, from above Maidenhead, through London, to the sea, for a distance of 50 miles, having a width varying from 2 to 9 miles, and a thickness of from 5 to 15 feet.* In many places it contains the bones and teeth of the Siberian Mammoth (*E. primigenius*) and Siberian Rhinoceros (*R. tichorhinus*), together with remains of the reindeer, horse, and other quadrupeds.

Recently (1855) three fossil skulls, referred by Prof. Owen to the Musk-buffalo (*Bubalus moschatus*), a well-known living inhabitant of Arctic regions, have also been discovered; one of them in the valley of the Thames at Maidenhead, and the other two in gravel of the same age at Batheaston, in the valley of the Avon.

The same musk-buffalo was met with about 20 years ago in the suburbs of Berlin, in the hill called the Kreuzberg, embedded in northern drift, and with it the Siberian Elephant and Rhinoceros, together with species of horse, deer, and ox.†

Among the fossil mammalia of another locality in the same drift of North Germany, Dr. Hensel, of Berlin, has detected, near Quedlinburg, the Norwegian Lemming, *Myodes lemmus*, and another species of the same family called by Pallas *Myodes torquatus*, (by Hensel *Misothermus torquatus*,) a still more Arctic quadruped found by Parry in latitude 82°, and which never strays farther south than the northern borders of the woody region. Professor Beyrich also informs me that the remains of the *Rhinoceros tichorhinus* were obtained at the same place.‡ In this "diluvium," as it is termed by many, no instance has as yet occurred in North Germany of the association of

Does Lemmg inhabit Alps. vide Walchen

* Prestwich Geol. Quart. Journ., vol. xii. p. 131.

† I was shown, in the Berlin Museum in 1856, part of the skull of the *Bubalus moschatus*, correctly named in the catalogue of the Museum for 1837, the year after its discovery, by Professor Quenstedt, at that time curator. The associated Kreuzberg fossils are enumerated in Leonhard and Bronn's Jahrbuch, 1836, p. 215.

‡ Zeitschrift der Deutsch. Geol. Gesellschaft, vol. vii. (1855), p. 548. &c.

the Hippopotamus, or any genus which would indicate a climate too warm for the reindeer, musk-ox, or lemming; so that it becomes more and more probable that the alleged association of the Mammoth (*E. primigenius*), in the valley of the Thames, with the hippopotamus and monkey (*Macacus pliocenus*), and a similar mixture of the bones and teeth of the tichorhine and leptorhine rhinoceros in the cliffs of Norfolk, may have arisen from confounding together the fossils of different deposits and periods, or from an intermixture, due to natural causes, of the fossil remains of more than one epoch.

Professor Owen remarks, that as the musk-buffalo has a constitution fitting it at present to inhabit the high northern regions of America, we can hardly doubt that its former companions, the warmly-clad Mammoth and the two-horned woolly rhinoceros (*R. tichorhinus*), were in like manner capable of supporting life in a cold climate.*

To what part of the Pliocene Period the Cave animals of Great Britain should be chiefly referred, is still a vexed question. There seems, however, no reason at present to suppose any of them more ancient than the Norwich Crag; and many caves may have remained open during the glacial and post-glacial eras, while the fauna was gradually changing, so that the remains found in them may not always belong to strictly contemporary quadrupeds.

I have mentioned (p. 176.) the occurrence in the suburbs of Rome of the remains of Elephants, and referred them to *E. primigenius;* but, according to Dr. Falconer, there is no well authenticated example of this species having ever been met with South of the Alps. The specimens from Monte Mario, and other localities near Rome, belong, according to him, to *E. antiquus*, Falc. and *E. meridionalis*, Nesti, and those in Piedmont and Lombardy to the same species, together with *Elephas priscus.*

WHERE TO DRAW THE LINE BETWEEN THE MIOCENE AND EOCENE TERTIARY STRATA, pp. 116. 176. 184.

Classification of the Miocene and Eocene strata — Where to draw the line between Upper Eocene and Lower Miocene — Reasons for a proposed change of nomenclature — Miocene fossil shells and quadrupeds of the Sewâlik or Sub-Himalayan hills.

I HAVE stated in the fifteenth chapter (p. 184.), that many eminent geologists consider the Marine Sands of the Forest of Fontainebleau, together with their equivalents in age in Belgium, Germany, and elsewhere, as the base of the Miocene division of the great Tertiary series. Accordingly, I have introduced in the table, at p. 106., the

* Geol. Quart. Journ., vol. xii. p. 124.

name of "Lower Miocene" as a synonym much in vogue on the Continent for strata of that age, called by me "Upper Eocene." It is unnecessary to repeat the reasons so fully set forth in the text, which induced the late Professor E. Forbes and me to employ this arrangement and nomenclature in preference to one which throws into the same division the faluns of Touraine (originally selected by me as the type of the Miocene), and a fauna so distinct as that of the Fontainebleau sands, which contains no species of shells in common with the "faluns," and which approaches so nearly in the general character of its fossils to the typical Eocene fauna. I observed, however (pp. 187, 188.), that I was not unprepared for the necessity of including hereafter the deposits above alluded to in one and the same Miocene Period, should sufficient evidence be brought to light of intermediate and connecting links between the Fontainebleau sands or Limburg beds and the faluns of Touraine.

In the course of the last two years some progress has certainly been made in bridging over the wide gulf which formerly separated the so-called "Lower Miocene" from the "faluns," while on the other hand the Eocene system is becoming so comprehensive and so complicated in its details by the continual intercalation of new formations, and by the addition below its former base of the Thanet sands and Lower Landenian of Belgium, that the desirability of limiting its extension in an upward direction is becoming more and more obvious. The Thanet Sands, moreover, exhibit a testaceous fauna, almost as divergent from that of the Barton clay as are the shells of the Fontainebleau Sands from those of the faluns; so that, if we comprise the Thanet and Barton beds in one Eocene Period, we may be called upon, with almost equal propriety, to class the Fontainebleau and Falunian faunas in one and the same great Miocene system.

Professor Beyrich, in a recently published memoir on the tertiary strata of the North of Germany*, has made known to us the existence of a long succession of marine strata, leading almost gradually from the equivalents of the Lowest Limburg or Tongrian beds of Dumont to others approaching in age the faluns of the Loire. Consequently he has thought fit to introduce a new term — that of "Oligocene" — for all the beds intermediate between Eocene and Miocene; and having distributed the strata in question into seven subdivisions, each characterized by a certain proportion of peculiar fossils, he refers the uppermost of all, or his Sternberger beds, to the "Upper Oligocene;" the next five, comprising among others the Upper and Middle Limburg, to the "Middle Oligocene;" and the remaining two to the Lower Oligocene, comprehending the Lower Tongrian of Dumont with the Brown-coal of Germany, which is classed as the lowest of all.

M. Alcide d'Orbigny had previously (1852), in his Paleontology, considered all these "Oligocene" beds as a Lower Falunian division,

* Abhandlungen der Königl. Acad. der Wissen zu Berlin, 1855.

classing the faluns of the Loire as Upper Falunian. Dr. Sandberger, in his writings on the fossils of the Mayence Basin, has lately pointed out several connecting links between the beds commonly called Lower Miocene and the overlying formations coeval with the faluns of Touraine. M. Raulin also, in a paper just printed on the faluns of the Gironde*, has given the names of Middle and Lower Miocene to the equivalents of the Fontainebleau and Limburg beds, or to Professor Beyrich's "Oligocene" strata, the faluns of Touraine being classed as "Upper Miocene."

M. Hébert published, in 1855, a map descriptive of the areas of two tertiary seas, which succeeded each other in the Paris Basin,—the first that of the Calcaire grassier, and the second that of the Fontainebleau Sands,—showing how marked is the want of coincidence between them; a fact which implies the occurrence of great geographical changes in the interval of time between the two eras compared. In the explanation of his map he gives his reasons for regarding the zone of *Cerithium plicatum*, or that of the Fontainebleau Sands, as the most convenient line of demarcation between Lower and Middle tertiary, or between Eocene and Miocene.† M. Lartet, also a distinguished French osteologist, whose writings on fossil mammalia are so well known, has favoured me with his valuable counsel on this controverted subject; observing, that although the fossil testacea of the Fontainebleau Sands show a preponderance of affinities towards an Eocene fauna, and small connection with the faluns of Touraine, yet, on the other hand, the freshwater "Calcaire de la Beauce," immediately overlying the Fontainebleau Sands, and other lacustrine formations in Auvergne and Central France, as well as the Mayence Basin, cannot be included in the same Eocene system without doing violence to paleontological principles. The grouping of the fossil mammalia, he remarks, becomes less natural by such an arrangement; for not only many genera, but even some species, are found on both sides of the arbitrary line of demarcation thus drawn between Eocene and Miocene. The genera *Dorcatherium*, *Cainotherium*, *Anchitherium*, and *Titanomys*, for example, and *Rhinoceros incisivus* and others, are made common to Eocene and Miocene.

Professor Forbes, in his posthumous memoir on a tertiary formation of fluvio-marine origin in the Isle of Wight‡, has observed, "There are certain bands of well-marked fossils so widely extended as to indicate definite horizons; and of these perhaps the most constant is 'the zone of *Cerithium plicatum*,' well-marked among the Tertiaries of France, Belgium, and Germany, and equally so in the Isle of Wight." Referring then to the connection between this zone and the underlying formations, he continues: "There is evidently no break in this part of the series of Tertiary depositions, and it would be harsh and forced to place one portion in the Eocene

* Actes de l'Académie de Bordeaux, 1855.
† Bullétin, 1855, tom. xii. p. 760.
‡ Mem. Geol. Survey, London, 1856, p. 99.

and another in the Miocene, as has been done by continental geologists. In the Isle of Wight we have the true clue to their relation clearly exhibited in unmistakeable and perfect sections; the importance of which clue in its bearing on continental geology may be estimated very highly."*

The opinion of my late lamented friend, so emphatically expressed in this passage in favour of the classification which I formerly adopted, will convince every reader that the old nomenclature might be defended by many cogent arguments; and some of these M. Deshayes has lately set forth in the preliminary chapter of his supplement to "The Fossil Shells of the Paris Basin;"† where he says, that while, on the one hand, the dissimilarity is enormous between the fossils of the Fontainebleau Sands and those of the faluns of the Loire, we find the fauna of the former to be allied to that of the marine beds below the Paris gypsum by a predominance of certain genera of shells. These he enumerates, and his observations are in harmony with what I have said (p. 185.) respecting the "Eocene aspect" of the testaceous fauna of those strata which occupy the debateable ground.

Notwithstanding these and many other arguments which might be adduced in support of the classification formerly advocated by me, and given in my Table at pp. 105–6, I have come to the conclusion that it will be more convenient to draw the line of separation in the place so generally adopted in France, provided that we always regard it as an arbitrary and purely conventional line,—one which has no pretensions to be founded on any great change of species, still less on any general revolution in the earth's physical geography assumed to have happened at the era referred to. The classification was originally suggested in France by an accidental break in the regular succession of *marine* strata, caused by the intercalation on the site of Paris of certain freshwater gypseous marls, in which the *Paleothere* and other quadrupeds were discovered. By these marls the marine sands of Beauchamp, often called the "Sables Moyens," were separated from the marine sands of Fontainebleau. In countries where no such interruption occurs, the series, whether composed of freshwater, fluvio-marine, or marine strata, will exhibit "beds of passage" between Eocene and Miocene, such as those of Hempstead in the Isle of Wight, or those recently discovered in the Alps by MM. Hébert and Rénevier, and described by them in the Bulletin of the Statistical Society of the department of the Seine (1854). In this interesting memoir an account is given of a formation termed by the authors "the Upper Nummulitic, which occurs in the neighbourhood of Gap, and in the Diablerets in Savoy, where the *Cerithium plicatum* and other shells usually accompanying it in the Fontainebleau sands and in Belgium, are abundantly intermixed

* Mem. Geol. Survey, London, 1856, p. 99.
† Description des Animaux sans Vertèbres, &c. Paris, 1857, p. 17.

with species frequent in the Grès de Beauchamp, and even in the inferior Calcaire Grossier. Here therefore, we have an example among the highly elevated and contorted strata of the Alps, of marine beds of passage of the period under consideration, remarkable for many reasons, and, among others, for the profusion of nummulites in association with shells characteristic of the Fontainebleau Sands. This association has obliterated one of the supposed distinguishing characters of the beds above and below the gypseous series, for nummulites have never been traced in Belgium, French Flanders, England or Germany above the zone of *Cerithium plicatum*, or if so, in extremely small numbers, and as exceptional cases. It was also thought by many geologists that the principal upheaval or disturbing movements of the Alps occurred exactly between the Lower and Middle Tertiary, or between the Eocene and Miocene epochs, as usually defined in France, whereas the plentiful occurrence of characteristic "Middle Tertiary" shells in the Diablerets, proves that the greatest movements of the Alps belonged to an epoch subsequent to the establishment of the *Cerithium plicatum* and many contemporary species in the Tertiary seas.

I am not yet prepared to divide the Miocene strata of Europe into Upper, Middle, and Lower, although the time is not far distant when such a subdivision will become necessary and possible. Meanwhile the following modification of the Table at pp. 105, 106. is proposed, consisting simply of a substitution of the term "Lower Miocene" for "Upper Eocene," and of a subdivision of the Middle Eocene of the same Table into two parts.

Proposed Modification of the Table of Fossiliferous Strata, pp. 105-106.

		British Examples.	Foreign Equivalents and Synonymes.
6.	**UPPER MIOCENE.**	Wanting in the British Isles.	Faluns of Touraine, p. 176. Bolderberg Strata in Belgium, p. 179. Sansans, near Pyrenees, South of France. Basin of Vienna, p. 180.
6.	**LOWER MIOCENE.**	Hempstead Beds, Isle of Wight, p. 193.	Grés de Fontainebleau, p. 195. Calcaire de la Beauce. *Ibid.* Mayence basin, p. 191. Limburg beds, Belgium, p. 189. " Oligocene " strata of North Germany. Nebraska beds in United States, p. 207.
7 *A.*	**UPPER EOCENE.**	1. Bembridge Beds, Isle of Wight, p. 209. 2. Osborne Series, p. 211. 3. Headon Series. *Ibid.* 4. Barton Clay, p. 213.	1. Gypseous Series of Montmartre, p. 224. 2 & 3. Calcaire Siliceux, p. 226; or Travertin inférieur. 4. Grés de Beauchamp, or Sables Moyens, p. 227. 4. Laeken beds, Belgium.
7 *B.*	**MIDDLE EOCENE.**	1. Bagshot and Bracklesham Beds, p. 214. 2. Wanting.	1. Calcaire Grossier of Paris basin, p. 227. 2. Upper Soissonnais, Sands of Cuisse-Lamotte, p. 229. 1 & 2. Nummulitic formation of Europe, Asia, &c., p. 230.
8.	**LOWER EOCENE.**	As in the table, p. 106.	

MIOCENE FAUNA OF THE SEWÂLIK HILLS, p. 183.

The genus *Dinotherium*, so characteristic of the Falunian or Upper Miocene period in Europe, occurs in India in strata of the same age. But as yet it has only been found in Perim Island, in the Gulf of Cambay, and not among the fossils of the Sewâlik or Sub-Himalayan Hills, as stated by mistake in the text (p. 183.). Seven species of Sewâlik elephants have been alluded to, whereas the number is in fact only five, three of which are referred by Dr. Falconer to the sub-genus *Stegodon*, comprising forms intermediate between the Mastodon and Elephant. The hippopotamus mentioned in the same page (183.), belongs to the sub-genus *Hexaprotodon*, a form now extinct. The *Anoplotherium posterogenium*, supposed when first discovered to present a generic link between the Sewâlik fauna and that of the Eocene period, is now recognised as a species of *Chalicotherium* (*Anisodon* of Lartet), a genus of pachyderms intermediate between the *Rhinoceros* and *Anoplothere*. The same genus occurs in Miocene or Falunian strata at Sansan, in the department of Gers, in the South of France. Among the Sub-Himalayan fossils, a giraffe, camel, and large ostrich may be cited as proofs that there were formerly extensive plains where now a steep chain of hills, with deep ravines, runs for many hundred miles east and west.

Fifteen species of fresh-water shells of the genera *Paludina*, *Melania*, *Ampullaria*, and *Unio*, were obtained by Sir P. Cautley and Dr. Falconer from the same strata, and when shown by them in 1846, to the late Prof. E. Forbes, were pronounced by him to be all extinct or unknown species, with the exception of four, which are still inhabitants of Indian rivers. Such a proportion of living to extinct species of Mollusca agrees well with the usual character of an upper Miocene or Falunian fauna, as observed in Touraine, or in the basin of Vienna and elsewhere.

DENUDATION OF THE WEALDEN. (Ch. XIX. pp. 272. 286.)

Denudation of the Wealden — Discovery of the Lower Crag on the summit of the North Downs between Folkestone and Dorking.

The arguments adduced in the 19th chapter, pp. 272—286., to prove that the denudation of the Wealden area took place at many successive periods, and at dates widely remote from each other, some of them antecedent to the deposition of the Lower Eocene strata of Great Britain, and others so late as the Pliocene epoch, have lately received an unexpected confirmation, for Mr. Prestwich has announced to the Geological Society of London (January 21st, 1857), the dis-

covery of marine sands of the crag period, resting on the summit of the North Downs at various points between Folkestone and Dorking. These ferruginous sands include layers of iron sandstone, and of quartzose sand, with flint pebbles, and occasionally green earth, the whole deposit resembling precisely in mineral character the sands of Diest, in Belgium, which have long been considered as of the same age as the older crag of Suffolk. The same *Terebratula grandis*, which abounds in the English crag, and in the sands of Diest; and the casts of *Astarte*, *Pyrula*, and other fossils, concur with the mineral character of the beds to prove the contemporaneous origin of these British and Belgian strata. At Paddlesworth, 4 miles W.N.W. of Folkestone, the irony sands, above mentioned, rest on an older flint gravel, at an elevation of between 600 and 700 feet above the sea, and near the edge of the chalk escarpment. Some idea of their exact position may be gained by the reader by supposing them placed on the heights marked by the strong black line above fig. 3. in the woodcut 321. (p. 274. of the text, 5th edition, and 4th edition p. 243.), or he may suppose the tertiary outlier *b*. fig. 329. (p. 283., 5th edition), to consist of Coralline crag, instead of being a mass of Eocene clay and sand.

It follows from such facts, that although the first elevation of the Wealden took place, as shown in the 19th chapter, in the early Eocene, or partly, perhaps, in the cretaceous period; and although much denudation was then effected, yet the same area was again submerged during the Older Pliocene epoch. The latest denudation, therefore, as well as the present escarpments, were brought about after the sea had become already peopled with species of mollusca, half of which are still living. The great upheaval of land in the Wealden area, thus proved to be subsequent in date to the Lower Crag, may, as Mr. Prestwich observes, help to explain the difference observed in the fauna and climate of the several successive crag periods (see above, p. 2.); for we may now with more confidence assume that the sea of the Coralline Crag was open to the south, so that shells of southern forms lived in it, until at length the bed of that sea having been upraised 650 or 700 feet, all communication with warmer latitudes was cut off, and the fauna of the Red Crag acquired its more boreal character.

We also learn from these recent discoveries how impossible it may often be to demonstrate the former presence of the sea on any given area by organic remains, or by sea-beaches. Long and diligent inquiries had been made before the year 1856, for sea shells of recent or crag species, and for the signs of old sea margins within the Wealden area, or on Nos. 3, 4, 5, 6, and 7. of the map (p. 273., 5th edition, and p. 242., 4th edition), and on the chalk downs and tertiary area between the Weald and the Thames (Nos. 1. and 2. *ib.*); but in vain, until at last a few casts of shells prove incontestibly the long sojourn of the Older Pliocene sea in those very spaces. We must now, therefore, admit the retreat of its waters to have been an event of times comparatively modern. It follows that in many cases

the land may have sunk and have emerged again without retaining on its surface any monuments of the kind usually demanded as indispensable, to warrant us in speculating on marine denudation as a great modifying cause in the physical geography of the globe.

NEW FOSSIL MAMMALIA FROM THE PURBECK OR UPPER OOLITIC STRATA IN DORSETSHIRE.

Discovery in Dorsetshire of seven or eight new genera of Mammalia in the Purbeck or Upper Oolite strata — First example of a skull of a Mammifer from Secondary Rocks —Insectivorous Marsupials and Placentals and herbivorous Marsupials — Figures and descriptions — Light thrown on the Microlestes or oldest triassic Mammifer — General bearing of the new facts.

It will be seen by the text (p. 461.) that when the 5th edition of this work was published two years ago, six species only of mammalia were known in the whole world from rocks older than the Tertiary. The researches of 36 years had been required to bring these six species to light, from 1818, when first a lower jaw from the Stonesfield Oolite, found 10 years before, was pronounced by Cuvier to be mammalian, to the year 1854, when the *Spalacotherium* of Purbeck was described by Owen.

Figures are given at p. 343. of two small molar teeth of the most ancient of these six quadrupeds, the *Microlestes* of Plieninger, found in a bone-bed near Stuttgart usually referred to the Upper Trias, and in which Triassic species of fish and reptiles abound. Figures are also given of the fossil lower jaws with teeth of three diminutive mammalia obtained from the inferior oolite of Stonesfield (pp. 312., 5th ed. and 368., 4th ed.), and supposed to belong to insectivorous creatures, one of them at least to a marsupial quadruped. The remains of a fourth British mammal, also consisting of a lower jaw from the same locality, found by the Rev. J. B. P. Dennis, and made known in September, 1854, is alluded to in a note at p. 461. Although small, it was considerably larger than the three species previously discovered, being probably about the size of a rabbit. Professor Owen imagines it to have been of omnivorous habits, one of the ungulate or hoofed quadrupeds, allied to certain extinct genera of the tertiary period, called *Hyracotherium*, *Microtherium* and *Hyopotamus*.

The discovery in Purbeck, Dorsetshire, in 1854, of the *Spalacotherium*, a small insectivore allied to the Cape mole, is mentioned at p. 296. and 461., as the first example of a mammifer from those freshwater strata. In December last (1856) Mr. Samuel H. Beckles, F. G. S., conversed with me in London on the desirability of quarrying the Middle Purbeck in Durlestone Bay, near Swanage, for the express purpose of exploring the fossil contents of the bed in which

Mr. W. R. Brodie had procured the *Spalacotherium*. The average thickness of this stratum called No. 93. or the "dirt-bed," is about 5 inches.* It lies at the base of the middle Purbeck, and consists of a soft marl, or calcareous mud, and contains the remains of a few insects with freshwater shells of several genera (*Paludina*, *Planorbis*, and *Cyclas*), and many reptiles. As the fruit of his second day's excavations (Dec. 11th) Mr. Beckles sent me the lower jaw of a mammal of a new genus, a discovery soon followed by others in rapid succession, so that at the end of three weeks there were disinterred from an area not exceeding 40 feet in length by 10 feet in width, the remains of five or six new species belonging to three or four distinct genera, varying in size from that of a mole to that of a hedgehog, besides the entire skeleton of a crocodile, the shell or carapace of a freshwater tortoise, and some smaller reptiles. While these investigations were in progress, Mr. W. R. Brodie of Swanage kindly forwarded to me at my request, the fossils which he had been accumulating during two years (1855 and 1856) from the same thin bed in a contiguous area no less limited in its dimensions. Besides reptilian remains there were among his acquisitions three lower jaws of three mammalian species, and Dr. Falconer, who interpreted for me the meaning of these and other fossils, as they arrived from day to day, called my attention to one slab in which was seen the upper portion of a skull, consisting of the two parietal bones in a good state of preservation, with the sagittal crest well marked, as also the connection with the frontals and the occipital crest. Although the lateral and basal portions of this cranium are wanting, enough remains to show that it agrees with the ordinary type of living warmblooded quadrupeds, implying probably a higher organisation than that of such genera as the Stonesfield *Phascolotherium* and *Amphitherium*, though affording no clear evidence whether the creature was placental or marsupial. It is singular that this specimen should have been the first example ever seen of a cranium, or indeed of any part of the skeleton of a mammifer other than a lower maxillary bone with teeth, from rocks more ancient than the tertiary. It supplied therefore a more significant kind of evidence to the osteologist than had previously been obtained of the exact correspondence in structure of the mammalia of a very remote period with the higher types of living vertebrata.

In the same slab with the cranium is one entire side of a lower jaw of a quadruped, for which Professor Owen proposes the generic name of *Triconodon*. It contains eight molars, a large and prominent canine, and one broad and thick incisor. This creature must have been nearly as large as the common hedgehog.†

* This so called "dirt-bed" is designated as No. 93. both in the Guide to the Geology of the Isle of Purbeck, by the Rev. G. H. Austen (1852), and by the Rev. O. Fisher, in his paper on the Purbeck strata. Trans. Camb. Phil. Soc., vol. lx. (1855). It has not the character of an ancient vegetable soil, as the name would seem to imply.

† The compressed crowns of the inferior molars in this *Triconodon* have each of them three subequal sharp-pointed

Several other jaws with similar tricuspid teeth of larger dimensions found by Mr. Beckles, indicate the existence of another species of *Triconodon* of a more elongated form, and about one third larger in size. From one of these the following evidence of its marsupial character was pointed out to me by Dr. Falconer. 1. The plurality of true molars. 2. The strong, inflected angular process. 3. (And this is considered by him the most significant of all), the broad, salient, everted rim of the ridge which is decurrent on the outer side from the condyle along the inferior margin, exactly as in the carnivorous marsupials. 4. The marked development of the mylo-hyoid groove. He also adds, that these two species of *Triconodon*, from the cutting character of their teeth, and their comparatively formidable canines, together with the form of the ascending ramus, are more like small ferine animals than mere insectivorous marsupials. It is most probable that they fed on prey less minute than insects.

Among the jaws of many smaller insectivora is one allied to the type of the Stonesfield *Amphitherium*, but generically distinct.*

The following observations by Professor Owen, on the genus *Triconodon*, extracted from a letter which I received from him January 27. 1857, are not the less interesting as having been written before the more decisive proofs above enumerated of the marsupial characters of *Triconodon* had been elicited from more perfect specimens obtained about a month later: — "The Purbeck fossil (the smaller *Triconodon*) is most nearly allied to the Stonesfield insectivorous genera, and shows characters intermediate between *Phascolotherium* and *Thylacotherium*. The three-coned tooth presents the same type as in the molars of these genera, but the first and third cones are developed to nearer equality with the second or mid-cone. The cingulum in *Triconodon* develops the same front and back talon. In the size of the canine, and in the depth and other proportions of the jaw, *Triconodon* resembles *Phascolotherium*, and so much so in the jaw-bone characters that if one be marsupial the other should be; but I cannot get a clear evidence of the inward bend of the angle, or of its extension backwards.

"In the superior number of molars, *Triconodon* resembles *Thylacotherium*, and also *Myrmecobius*, which, by the way, has a somewhat similar type of molar tooth. The above cited genera and *Spalacotherium* have enough of characters in common, so far as regards mandible and mandibular teeth, to suggest their all belonging to the same natural group of an insectivorous and very probably marsupial

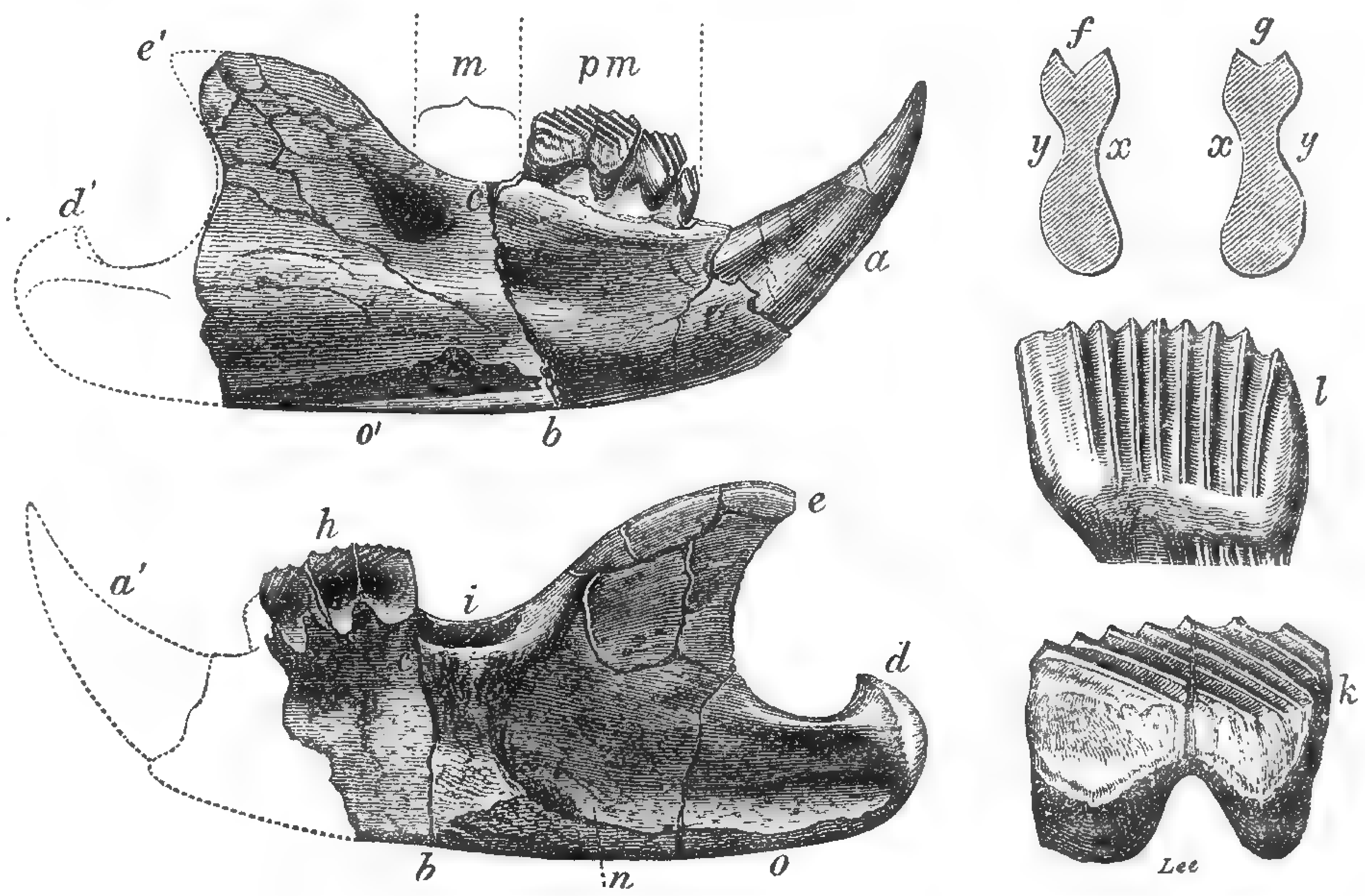
cusps, rising nearly vertically into the same longitudinal plane, with basal end lobules, but without additional interior complication. They are so arranged, in a continuous and compact series, as to present a uniform serrated edge, like the teeth of a saw.—*Dr. Falconer*.

* In this species the lower jaw has an elongated slender ramus, containing 7 uniform back molars in situ, and the empty alveoli of 4 or 5 false molars in front, together with a prominent laniariform tooth. The dental formula agrees numerically with that of the Amphitherium, but differs from it in the double-rowed and complex arrangement of the crown-cusps.—*Dr. Falconer*.

family. The character of the calvarium of *Triconodon* offers nothing adverse to the above views." *

Besides the mammalia above alluded to belonging to 9 or 10 species and to 5 or 6 genera, all of them insectivorous or predaceous, we are indebted to Mr. Beckles for having disentombed (January 31. 1856) the remains of another genus exceedingly unlike the rest, the

Fig. 1.



Plagiaulax Becklesii, Falc.†

These two figures represent the same right ramus of the lower jaw seen on the opposite surfaces of a split stone, the two taken together affording data for a complete restoration of the jaw.

Upper figure (outer side).

a, b, e'. Right ramus of lower jaw magnified two diameters. *a, b*, outer side. *b, o', d', e'*, impression of inner side.

- ***a***. Incisor.
- ***b, c***. Line of vertical fracture behind the pre-molars.
- ***d'***. Impression in the matrix of the condyle.
- ***e'***. Impression of top of coronoid process.
- ***f***. Section of the anterior piece of the jaw at the fracture *b, c*,—*x*, inner surface; *y*, outer. The notch at the top is formed by one of the sockets of the double-fanged true molar.
- ***g***. Section of the hinder piece near *b, c*; *x*, inner; *y*, outer surface.
- ***o'***. Broken off inflected fold of inner margin buried in the matrix.
- ***m***. Sockets of two molars.
- ***p, m***. Three pre-molars, the third and last divided by a crack.

Lower figure (inner side).

a', d. Same lower jaw on the opposite slab of stone; *b, d, e*, inner side; *b, a', h*, cast and impression of outer side.

- ***a'***. Outline of the incisor restored.
- ***b, c***. Line of vertical fracture.
- ***d***. Condyle.
- ***e***. Coronoid.
- ***h***. Impression on the matrix of the three pre-molars.
- ***i***. Empty sockets of the two true molars.
- ***n***. Orifice of dentary canal.
- ***o***. Indication of the raised and inflected fold of the posterior inner margin.
- ***k***. Third or largest pre-molar, magnified $5\frac{1}{2}$ diameters, showing the 7 diagonal grooves.
- ***l***. Corresponding pre-molar in the recent Australian Hypsiprymnus Gaimardi, showing the 7 vertical grooves, magnified $3\frac{1}{2}$ diameters.

* Allusion is here made to the crown of the skull before-mentioned as occurring in the same slab.

† The artist, in the lower figure, has made the point of the coronoid (*e*) project too much backwards, and the curve of the posterior margin too great, the line being nearly vertical in the original. The projection of the condyle behind the coronoid margin is more considerable than is shown by the figure, and the neck longer.

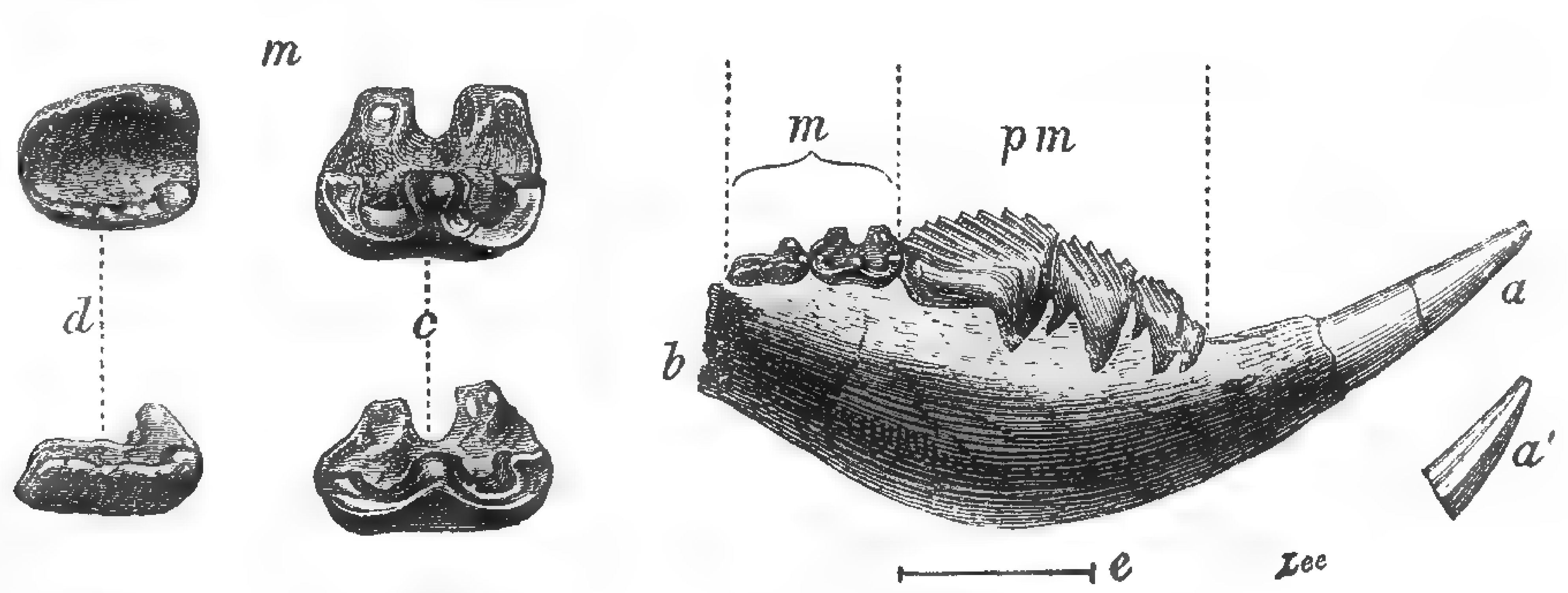
relations of which to the living kangaroo-rat were immediately recognised by Dr. Falconer on its first arrival in London.*

No less than 10 species of the living genus *Hypsiprymnus*, commonly called the kangaroo-rat, and referred by Waterhouse to the *Macropodidæ*, or kangaroo family, inhabit the prairies and scrub-jungle of Australia, feeding on plants and gnawing scratched-up roots. A striking peculiarity of their dentition, one in which they differ from all other quadrupeds, consists in their having a single large pre-molar, the enamel of which is furrowed with 7 vertical grooves (see *l*, fig. 1., where the pre-molar of the recent *Hypsiprymnus Gaimardi* is represented).

The largest pre-molar in the fossil genus exhibits in like manner seven parallel grooves, producing by their termination a similar serrated edge in the crown; but their direction is diagonal, a distinction, says Dr. Falconer, which is "trivial, not typical."

As these *oblique furrows* form so marked a character of the majority of the teeth, Dr. Falconer has proposed for the fossil the generic name of *Plagiaulax*. The shape and relative size of the incisor *a*, figs. 1. and 3., exhibit a no less striking similarity to

Fig. 2.



Plagiaulax minor, Falc.
(Magnified 4 diameters.)

All the teeth in this specimen are in place and well preserved. The hinder part of the jaw-bone, with the ascending ramus and posterior angle, are broken away.

a, b. Right ramus of lower jaw, with all the teeth magnified 4 diameters.
a. Incisor with point broken off. *a'*, impression of same, showing that the inner side near the apex was hollowed out in a longitudinal direction.
b. Offset of coronoid, the rest of which is wanting.
m. The two true molars.
p, m. The four pre-molars.
c. The first molar, magnified 8 diameters.
Upper figure, the crown. Lower figure, side view.
d. Second molar, crown and side view.
e. Straight line indicating the length of the jaw, natural size.

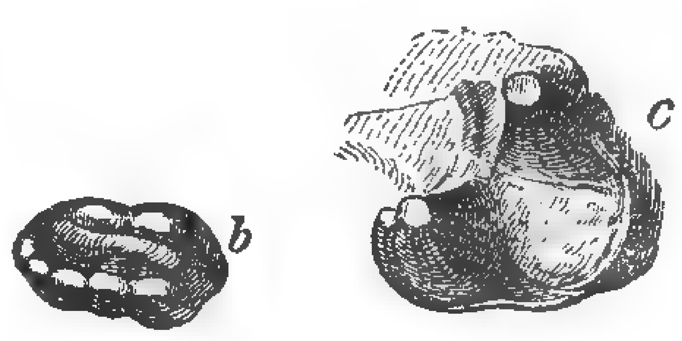
Hypsiprimnus. Nevertheless, the more sudden upward curve of this incisor, especially in the larger species, as well as the number and characters of the other teeth, and the shortening compression and depth of the jaw, taken together with the backward projection of the condyle (*d*, fig. 1.), indicate a great deviation in the form of *Plagiaulax* from that of the living kangaroo-rats.

Our knowledge is at present confined to two specimens of lower

* All the information concerning the natural history, osteology, and affinities of Plagiaulax given in the following pages, is extracted from a more detailed paper by Dr. Falconer, shortly to be published by the Geological Society, the MS. copy of which has been liberally placed at the author's disposal.

jaws*, evidently referable to two distinct species, extremely unequal in size and otherwise distinguishable. The largest *P. Becklesii* (fig. 1.) was about as big as the English squirrel or the flying phalanger of Australia (*Petaurus Australis,* Waterhouse). The skeleton of this phalanger (named *P. macrurus,* No. 1849, Museum of College of Surgeons) measures 15 inches in length, exclusive of the tail, which is more than 11 inches long. The smaller fossil (*P. minor*, fig. 2.), having only half the linear dimensions of the other, was probably only 1-12th of its bulk. To the geologist, however, it is perhaps the more interesting of the two, as Dr. Falconer has recognised in its two back molars (*c, d,* fig. 2.) an unmistakeable resemblance to those of the Triassic *Microlestes* (*b, c,* fig. 3.).

Fig. 3.



Teeth of *Microlestes antiquus*, Plieninger, from the Upper Trias of Wirtemburg.
b. Crown of the smaller molar (*b*, fig. 441., p. 343., 5th ed.) magnified.
c. Crown of larger tooth (fig. 442. ibid.), with part of the crown broken off.

Of this most ancient of known fossil mammalia an account is given in the text at p. 343., with illustrations, among which, however, there was no figure of the crown of the larger molar, which is now added, with a new illustration of the crown of the smaller tooth. No naturalist on the Continent to whom I had previously shown casts and drawings of these teeth, had been able to give any feasible conjecture as to its affinities. Plieninger considered it to be predaceous, whence the name; others fancied they saw some likeness in the form of its grinders to those of an omnivorous pachyderm, as well as of an Insectivore; while Professor Owen at once recognising the mammalian character of the double-fanged teeth, said they were distinct from any type known to him. When these grinders of *Microlestes* (fig. 3.) are compared to those of *Plagiaulax minor* (*d, c,* fig. 2)., the reader will agree with Dr. Falconer, that "had they all been found detached in the same slab they might have been taken for back and front, or for upper and lower teeth of the same or some cognate species, the essential characters of the crown being identical†; whereas, had the last molar and last pre-molar of *Plagiaulax* been found fossil under similar circumstances, they would in all probability have been taken for teeth not merely of different genera, but even of different orders of mammalia."

Two principal questions, observes Dr. Falconer, deserve our consideration with reference to *Plagiaulax;* namely, first, Was it marsupial? secondly, Was it herbivorous? The general resemblance of the jaws and teeth to those of the living Kangaroo-rats raises at

* Three additional specimens of *P. Becklesii* have since arrived, some with the two back molars entire. They confirm all the conclusions set forth in the following pages, and especially the affinity of Plagiaulax and Microlestes.

† The last back molar, whether of *Microlestes* or *Plagiaulax*, has two opposed longitudinal marginal ridges, more or less lobed or crenated, and separated by a depressed disk. In the next or larger molar of *Plagiaulax*, the cusps are not symmetrical on the two sides, there being two on the inner, and only one alternating lobe on the outer; and such seems to have been the case in the larger imperfect tooth of *Microlestes* (*c*, fig. 3.).

once a strong presumption in favour of the affirmative on both these points. There is, as before noticed, a distinct indication in the fossil of a bending inwards, or towards the observer, of the posterior inner margin of the jaw *o*, fig. 1. (lower figure), stretching from the anterior boundary of the dentary foramen *n*. The significance of this character will be appreciated by referring to what was said of such an inflection in reference to the Stonesfield Mammalia (p. 312., figs. 379. 381.). In both species the true molars are limited to two; yet the jaw of *P. Becklesii* was clearly that of an adult, having its full complement of teeth. This is an unexpected number in a quadruped inferred to be marsupial, in which tribe the normal number of molars should be four. In both species, moreover, the true molars are dwarfed in size, as well as reduced in number.

In the Kangaroo-rat there is a single grooved pre-molar and four back molars, while in *Plagiaulax*, the true molars being reduced to two, we find, as if in compensation, three or four grooved pre-molars. In the pigmy flying opossum of Australia (*Acrobata pygmæa*) there is an analogous development of pre-molars with a reduction of the back grinders to three; and in the Sub-genus *Dromicia*, or pigmy phalanger, there are four pre-molars, while the back molars are reduced to three. In the living *Myrmecobius** the true molars are greatly in excess of the normal number; while in the fossil *Plagiaulax* they are few and rudimentary, fewer even than in any of the placental herbivora. It is true that in general form the coronoid (*e*, fig. 1.) of *Plagiaulax* resembles more that of the predaceous marsupials, and of *Dasyurus* especially, than of the herbivorous families; but on the other hand it is less elevated, and its surface of less area, than in the predaceous genera, whether marsupial or placental.

The condyle (*d*, fig. 1.), which is well preserved, is remarkable for its depressed position, — a character which, considered apart from all the rest, might have been taken to indicate a beast of prey; but it is counterbalanced by another peculiarity without example, so far as Dr. Falconer is aware, among the predaceous genera, whether marsupial or placental; viz., the long neck and horizontal projection of the condyle *d* behind the coronoid *e*. The other leading indications imply a vegetable feeder; viz., the limited surface and moderate elevation of the coronoid above the plane of the teeth, the feeble development of the inflected margin, the absence of a thick angular process, the advanced position of the orifice of the dentary canal (*n*, fig. 1.), and the offset of the inflected margin above it. These characters, taken in conjunction with those of the teeth, would place the *Plagiaulax* with the vegetable feeders; and the exceptional position of the condyle may be a special modification having reference to the abnormal character of the teeth; *i. e.*, the excessive development of the premolars and the reduced number and size of the true molars.

* A figure of the lower jaw of this quadruped is given in my Principles of Geology, ch. ix. p. 138., 9th ed.

"The condyle of *Plagiaulax*, therefore," observes Falconer, "inculcates an emphatic warning against too much stress being laid upon any single character in Palæontological determinations." And he adds that this ancient fossil is interesting not only for its affinity to the existing Kangaroo-rat of Australia, but also as seeming to furnish a crucial test of the soundness, in some respects, of certain generalisations which have been put forward respecting the order of the successive appearance of mammalia upon the surface of the earth. It is maintained by some British palæontologists and comparative physiologists of high authority, that while there is no positive proof of serial progressive development from the lower to the higher forms, there is clear evidence of another order of development or passage, viz., from the *general* to the *special*, as we descend from the oldest tertiary to the modern period. It is urged by the advocates of this doctrine, that the mammalia of the Eocene Period assimilated more to the general archetype and embryonic condition of vertebrate organisation, while the mammalia of later times successively furnish examples of increasing deviation from the original or normal type as well as of special adaptation. Among other arguments, they insist that the earliest Eocene mammalia, both herbivorous and carnivorous, possessed in most cases the full complement of teeth; while forms characteristic of later times, such as the *Felidæ* and *Ruminantia*, are remarkable for special suppression of these organs. If the generalisation were really of as wide an application as has been claimed for it, we ought, in every great family of the mammalia, to find evidence of closer adherence to the archetype the further we recede in time. But so far is this from being the case, that *Plagiaulax*, the oldest well-ascertained herbivorous mammal, presents to us the most special exception to be met with in the whole range of marsupialia, fossil or recent. It had the smallest number of true molars of any known genus in that sub-class; thus exhibiting at the most distant end of the chain the very characters which, under the influence of the assumed law, we ought only to have found in some type of existing marsupials.

While the MS. of these pages was preparing for the press (February 10. 1857), part of the cranium of a mammal was received from Mr. Beckles, comprising the two superior maxillary bones and teeth, with the intermediate palate crushed, of a small insectivore. On the right side of the jaw the whole series of molar teeth and the incisors are seen. The grinders are more numerous, but the dental characters, says Dr. Falconer, bear a relation to those of the insectivorous genus *Ericulus*, peculiar to Madagascar, and from the general bearing of the evidence, it is presumed that the fossil was a minute Placental Insectivore.*

This was the first example of an upper jaw with teeth of a fossil

* Although the teeth differ considerably in shape from those of the other Purbeck fossils, it is just possible that this creature may be the same as some of the minuter species above alluded to, and known as yet only by their lower jaws.

mammal obtained from any secondary rock, and only five* such jaws were procured by Mr. Beckles when the entire number found by him had amounted (March 20th) to twenty-eight. The other seven specimens found at Purbeck by Mr. Brodie, consisted in like manner of lower jaws; and the same may be said of the ten specimens (belonging to four species) of oolitic mammalia hitherto discovered at Stonesfield.

That between forty and fifty pieces or sides of lower jaws with teeth should have been found in oolitic strata, and with them only five upper maxillaries, together with one portion of a separate cranium, will naturally excite surprise.† There are no examples of an entire skeleton, nor of any considerable number of bones in juxtaposition. In several portions of the Purbeck matrix there are detached bones, often much decomposed, and fragments of others apparently mammalian; but if all of them were restored, they would scarcely suffice to complete the five skeletons to which the five upper maxillaries above alluded to belonged. As the average number of pieces in each mammalian skeleton is about 250, there must be many thousands of missing bones; and when we endeavour to account for their absence, we are almost tempted to indulge in speculations like those once suggested to me by Dr. Buckland, when he tried to solve the enigma in reference to Stonesfield:—"The corpses," he said, "of drowned animals, when they float in a river, distended by gases during putrefaction, have often their lower jaw hanging loose, and sometimes it has dropped off. The rest of the body may then be drifted elsewhere, and sometimes may be swallowed entire by a predaceous reptile or fish, such as an icthyosaur or a shark."

We may also suppose that when fish or other aquatic animals attack a decaying carcase, whether it be floating or has sunk to the bottom, they will first devour those parts which are covered with flesh. A lower jaw, consisting of little else than bones and teeth, will be neglected, and becoming detached, may be drifted away by a current of moderate velocity, and buried apart from the other bones in sand or mud.

Among the latest discoveries of Mr. Beckles (March 19th), is the lower jaw of a small, adult, predaceous quadruped, with a robust canine and only six molars, differing in this respect as well as in its other characters, so far as the evidence at present extends, from the marsupial type.

The small average size of the species as yet made out, is worthy of notice, the two largest of them not exceeding by more than a

* The second of these is a fragment of the facial part of the cranium of Triconodon, received from Mr. Beckles, February 18th. It consists of the right maxillary bone, containing some of the molar teeth, together with a considerable portion of the palate uncrushed.

† As specimens of mammalia are arriving weekly from Mr. Beckles, we may expect a great addition to the number of individuals, as well as an increase in the number of species, before his labours terminate. To gain access to these treasures, he has already at his own cost removed nearly 3000 tons' weight of stone overlying the bed No. 93.

third the dimensions of the common hedgehog or the squirrel. On this subject Dr. Falconer observes, that in the Miocene freshwater deposit of Sansans, in the Department of Gers, near the Pyrenees (so well explored by M. Lartet), there is a layer in the marginal part of the basin in which the bones of diminutive mammalia, such as shrews and others, are mixed with remains of frogs in profusion; while in a more central part of the same basin, entire carcases of the *Mastodon* and other huge animals occur. In like manner the thin layer No. 93. in Purbeck may represent the shallow margin of a river, lake, or lagoon, in the deeper parts of which fossil animals of greater size may be preserved.

On a review of all the fossils collected by Messrs. Brodie and Beckles, including the original *Spalacotherium*, together with a lower jaw belonging to the Rev. P. B. Brodie, and communicated to me by Prof. Owen, it appears that we now possess (March 14th), the evidence of about fourteen species of mammalia from the Middle Purbeck, to say nothing of numerous remains of the highest osteological interest, respecting which no opinion can be hazarded until they have been studied more in detail. They belong to eight or nine genera, some insectivorous or predaceous, others having affinities as yet doubtful, and one of a purely herbivorous type, allied to the Kangaroo-rat of Australia. Some of the predaceous species were marsupial, some of them, in the opinion of Dr. Falconer, probably placental.

As all of them have been obtained from an area less than 500 square yards in extent, and from a single stratum not more than a few inches thick, we may safely conclude that the whole lived together in the same region, and in all likelihood they constituted a mere fraction of the mammalia even of one hydrographical basin. They afford the first positive proof as yet obtained of the co-existence of a varied fauna of the highest class of vertebrata, with that ample development of reptile life which marks all the periods from the Trias to the Lower Cretaceous inclusive, and with a gymnospermous flora, or that state of the vegetable kingdom when cycads and conifers predominated over all kinds of plants, except the ferns, so far at least as our present imperfect knowledge of fossil botany entitles us to speak.

The annexed table will enable the reader to see at a glance how conspicuous a part, numerically considered, the mammalian species of the Middle Purbeck now play when compared with those of other formations more ancient than the Paris gypsum, and at the same it will help him to appreciate the enormous hiatus in the history of fossil mammalia, which at present occurs between the Purbeck and Eocene Periods.*

* In drawing up this table I have been assisted by Professor Owen, in reference to the British, and by MM. Lartet and Hébert in reference to the French Eocene strata. There are, besides, several undescribed species in the collection of the two last mentioned paleontologists, or in museums known to them, and in regard to one or two of the Eocene continental localities out of the Paris basin, the age of the deposits is too little known to allow us to include their fossils in the Table.

Number and Distribution of all the known Species of Fossil Mammalia from Strata older than the Paris Gypsum, or than the Bembridge Series of the Isle of Wight.

TERTIARY.	Headon Series and Beds between the Paris Gypsum and the Grès de Beauchamp.	14	10 English. 4 French.
	Barton Clay and Sables de Beauchamp	0	
	Bagshot Beds, Calcaire Grossier, and Upper Soissonnais of Cuisse-Lamotte.	20	16 French. 1 English. 3 U. States.*
	London Clay, including the Kyson Sand	7	All English.
	Plastic Clay and Lignite	9	7 French. 2 English.
	Sables de Bracheux	1	French.†
	Thanet Sands and Lower Landenian of Belgium	0	
SECONDARY.	Maestricht Chalk	0	
	White Chalk	0	
	Chalk Marl	0	
	Upper Green Sand	0	
	Gault	0	
	Lower Green Sand	0	
	Weald Clay, &c.	0	
	Hastings Sand	0	
	Upper Purbeck Oolite	0	
	Middle Purbeck Oolite	14	Eng. (Purbeck.)
	Lower Purbeck Oolite	0	
	Portland Oolite	0	
	Kimmeridge Clay	0	
	Coral Rag	0	
	Oxford Clay	0	
	Great Oolite	4	Eng. (Stonesfield).
	Inferior Oolite	0	
	Lias	0	
	Upper Trias	1	Wurtemberg (Stuttgardt).
	Middle	0	
	Lower	0	
PRIMARY.	Permian	0	
	Carboniferous	0	
	Silurian	0	
	Cambrian	0	

After what has been said at the close of the 27th chapter, pp. 460, 463, and at 405, ch. xxv. I have little to add in regard to the bearing of these discoveries in Purbeck, on some geological theories hastily embraced, in favour of the non-existence or scarcity, at particular periods, of certain classes of air-breathing animals, on the ground of our not happening at present to have met with any fossil representatives of the same. It is worthy, however, of notice, that in the Hastings Sands there are certain layers of clay and sandstone in which numerous foot-prints of quadrupeds have been found by Mr. Beckles, and traced by him in the same set of rocks through Sussex

* I allude to several Zeuglodons found in Alabama, and referred by some zoologists to three species.

† The Sables de Bracheux, although somewhat older than the Plastic clay, are supposed by Mr. Prestwich to be newer than the Thanet Sands. They have yielded at La Fére the *Arctocyon* or (*Palæocyon*) *primævus*, the oldest known tertiary mammal.

and the Isle of Wight. They appear to belong to 3 or 4 species of reptiles, but no one of them to any warm-blooded quadruped. They ought, therefore, to serve as a warning to us when we observe a similar absence of such foot-prints in older rocks, to refrain from inferring that quadrupeds, other than reptilian, did not exist or pre-exist.

But the most instructive lesson read to us by the Purbeck strata, consists in this:—They are all, with the exception of a few intercalated brackish and marine layers, of fresh water origin; they are 160 feet in thickness, have been well searched by skilful collectors, and by the late Edward Forbes in particular, who studied them for months consecutively. They have been numbered, and the contents of each stratum recorded separately, by the officers of the Government Survey of Great Britain. They have been divided into three distinct groups by Forbes, each characterised by the same genera of pulmoniferous mollusca and cyprides, but these genera being represented in each group by different species; they have yielded insects of many orders, and the fruits of several plants; and lastly, they contain "dirt beds," or old terrestrial surfaces and soils at different levels, in some of which erect trunks and stumps of cycads and conifers, with their roots still attached to them, are preserved. Yet when the geologist inquires if any land animals of a higher grade than reptiles lived during any one of these three periods, the rocks are all silent, save one thin layer a few inches in thickness, and this single page of the earth's history suddenly reveals to us in a few weeks the memorials of so many species of fossil mammalia, that they already outnumber those of many a sub-division of the tertiary series, and far surpass those of all the other secondary rocks put together!

It is remarked by Professor Owen that many of the Purbeck Insectivora belong to the same natural family as those of Stonesfield. Some at least of them were Marsupials, and Dr. Falconer has pointed out that the *Plagiaulax* of Purbeck, an herbivorous marsupial, was so much allied to the *Microlestes* of the Trias as to lead us to infer that that more ancient mammifer was likewise a pouched quadruped, having some affinity to the living Kangaroo-rat.

In Australia and the neighbouring islands about 100 species of marsupials exist, together with a certain number of placentals (bats and rodents), while the fossil species of that continent show that kangaroos, wombats, Tasmanian wolves (or *Thylacines*), Dasyures, and other marsupials of species now extinct, preceded the present creation. Although the localities of Stuttgardt, Stonesfield, and Purbeck do not relate to an area larger than the middle island of New Zealand, yet there may have prevailed, during the Oolitic period, throughout a much wider space in European latitudes, certain geographical and climatal conditions and a peculiar vegetation, favourable to a fauna more analogous to that of the present Antipodes than to that of modern Europe. During the Upper Triassic, the Liassic and Oolitic epochs, one assemblage of such quadrupeds may have succeeded to another, until at a later era, and after the interval

marked by the Wealden and Cretaceous rocks, another and a different geographical state of things being established, the tertiary mammalia of Europe entered on the stage and occupied the same area.

The advocates, however, of the doctrine of progressive development will offer a different explanation of the phenomena. They will refer the large admixture of marsupials in the Stonesfield and Purbeck fauna to chronological rather than to climatal conditions, — to the age of the planet rather than to the state of a portion of its dry land. In the Triassic and Oolitic periods they will say the time had not yet come for the creation or development of more highly organised beings. Experience must test and determine the soundness of these theoretical views. In the meanwhile it may be useful to bear in mind that while Australia supports at present 100 species of marsupials, the rest of the continents and islands of the globe are tenanted by about 1,700 species of mammalia, of which only 46 are marsupials (namely, the opossums of North and South America), and in like manner there flourished in the Pliocene period throughout Europe, Asia, and America, so far as we yet know, a placental fauna, consisting of species now for the most part extinct, which was coeval with the extinct Pliocene marsupials of Australia. Such facts, although far too limited to enable us to generalise with confidence, seem rather to imply that at certain periods of the past, as in our own days, the predominance of certain families of terrestrial mammalia has had more to do with conditions of space than of time, or in other words has been more governed by geographical circumstances than by a law of successive development of higher and higher grades of organisation, in proportion as the planet grew older.

UPPER TRIAS OF THE EASTERN ALPS (p. 337.).

Recognition of a Marine equivalent of the Upper Trias in the Austrian Alps — True position of the St. Cassian and Hallstatt Beds — 800 new species of triassic Mollusca and Radiata — Links thus supplied for connecting the Palæozoic and Neozoic faunas.

The true position in the series of certain Alpine rocks called "the St. Cassian beds," has long been a subject of doubt and discussion, but the researches of many eminent geologists, among others MM. Von Buch, E. de Beaumont, Murchison, and Sedgwick, and in Switzerland MM. Escher and Merian, and more lately in Austria MM. Von Hauer, Suess, and Hörnes, have shown that these rocks are unquestionably referable to the Keuper or Upper Trias. It has also been proved that the Hallstatt beds on the northern flanks of the Austrian Alps correspond in age with the St. Cassian beds on their

southern declivity. By these discoveries we become acquainted, suddenly and unexpectedly, with a rich marine fauna belonging to a period previously believed to be very barren of organic remains, because in England, France, and Northern Germany the Upper Trias is chiefly represented by beds of fresh or brackish water origin. Mr. Edward Suess, of Vienna, to whom we are indebted for several memoirs on the rocks in question, has favoured me with the following summary of the order of succession of the Hallstatt beds in the Austrian Alps, which I had an opportunity, when travelling in the autumn of 1856, of verifying in company with Mr. Gümbel, of Munich.

The uppermost strata first enumerated immediately underlie the Lower Lias of the Swabian Jura. This lias is represented near Vienna by a brown limestone, containing Ammonites Bucklandi, A. Conybearii, &c.

Infra-liassic (?) Strata of the Austrian Alps, in descending Order.

1. Koessen beds. (Synonyms, Upper St. Cassian beds of Escher and Merian ; Upper Trias ? or intermediate between Lias and Trias ?)	Grey and black limestone with calcareous marls, having a thickness of about 50 feet. Among the fossils, Brachiopoda very numerous ; some few species common to the genuine Lias ; many peculiar. *Avicula contorta, Pecten Valoniensis, Cardium Rhæticum, Avicula inæquivalvis, Spirifer Münsteri,* Dav. Strata containing the above fossils alternate with the Dachstein beds, lying next below.	
2. Dachstein beds, between Lias and Trias ?	White or greyish limestone, often in beds 3 or 4 feet thick. Total thickness of the formation above 2000 feet. Upper part fossiliferous, with some strata composed of corals. (*Lithodendron.*) Lower portion without fossils. Among the characteristic shells are *Hemicardium Wulferii, Megalodon triqueter,* and other large bivalves.	
3. Hallstatt beds (or St. Cassian). Upper Trias.	Red, pink, or white marble, from 800 to 1000 feet in thickness, containing more than 800 species of marine fossils, for the most part mollusca. Many species of *Orthoceras.* True *Ammonites,* besides *Ceratites* and *Goniatites, Belemnites* (rare), *Porcellia, Pleurotomaria, Trochus, Monotis salinaria,* &c.	
4. *A.* Guttenstein beds. *B.* Werfen beds, base of Upper Trias ? Lower Trias of some geologists.	*A* Black and grey limestone 150 feet thick, alternating with the underlying Werfen beds. *B.* Red and green shale and sandstone with Salt and Gypsum.	Among the fossils are *Ceratites cassianus, Myacites fassaensis, Naticella costata,* &c.

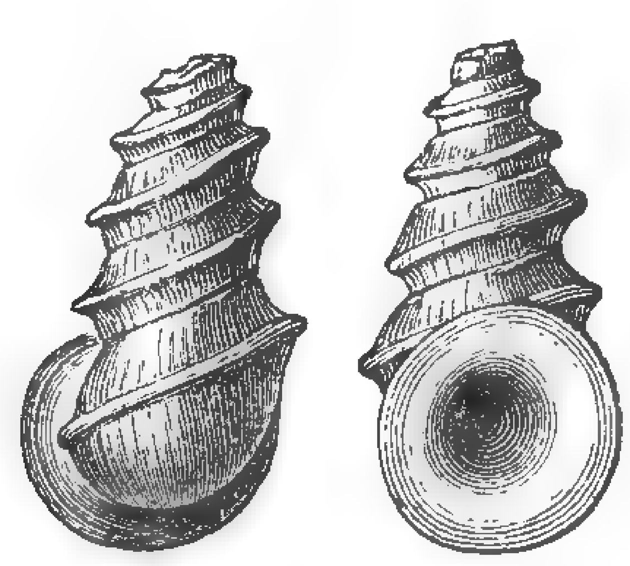
In regard to the age of the rocks above mentioned, the Koessen and Dachstein beds are referred by some to the Lias, by others to the Trias, while many consider them to be of intermediate date. According to Mr. Suess, the Koessen beds correspond to the upper bone-bed of Swabia, in which the *Microlestes* was found (see p. 342.), but it should not be forgotten that that stratum contains true triassic species of reptiles and fish. On the whole, the beds 1. and 2. contain a very peculiar fauna, and Mr. Suess remarks that some of the fossils are identical with the Irish "Portrush beds" of Colonel Portlock,

described in his report on Londonderry. The Koessen beds have been traced for 100 geographical miles from near Geneva to the environs of Vienna.

Whatever doubts may be entertained respecting the exact age of the beds Nos. 1. and 2., there is now no longer any dispute that the Hallstatt and St. Cassian beds agree in age with the Keuper or Upper Trias; but whether the Werfen sandstone, No. 4., should form part of the same series, or, as Von Hauer inclines to believe, should be classed as the equivalent of "the Bunter or Lower Trias," is still undetermined. The absence of well-characterised Muschelkalk fossils in the Austrian Alps renders this point very difficult to decide. Rich deposits of salt, associated with the Werfen beds, incline some geologists to presume that they belong to the Upper Trias. Should they be classed as "Bunter," the Guttenstein limestone would then correspond in position with the Muschelkalk, but no Muschelkalk fossils have ever been met with in it or in the Werfen; while, on the other hand, the true Muschelkalk is known to exist in the Italian Alps and in Hungary, so that all doubts on this question must very soon be removed.

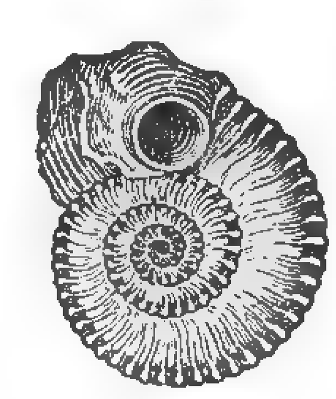
Among the 800 species of fossils of the Hallstatt and St. Cassian beds, many are still undescribed; some are of new and peculiar genera, as *Scoliostoma*, fig 1., and *Platystoma*, fig. 2.; among the Gasteropoda and *Koninckia*, fig. 3., among the Brachiopoda.

Fig. 4.



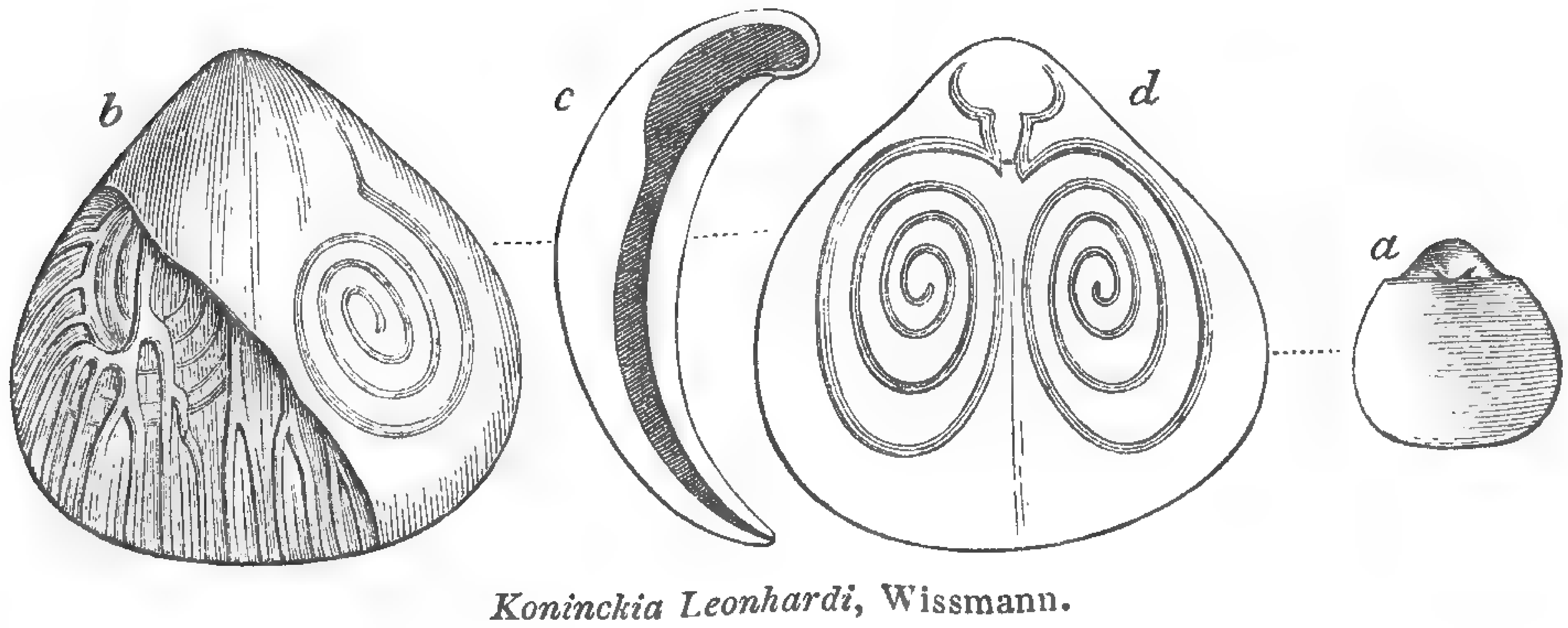
Scoliostoma, S. Cassian.

Fig. 5.



Platystoma Suessii, Hornes.
From Hallstatt.

Fig. 6.



Koninckia Leonhardi, Wissmann.

a. Dorsal view, natural size.
b. Ventral view, part of the converse ventral valve removed to show the interior of dorsal valve and its vascular impressions. One of the spiral processes is seen through the translucent shell.
c. Section of both valves.
d. Interior of dorsal valve, with spiral processes restored. (Suess.)

The following table of genera of marine shells from the Hallstatt

and St. Cassian beds, drawn up on the joint authority of MM. Suess and Woodward, shows how many connecting links between the fauna of primary and secondary rocks are now supplied by the Upper Trias.

Genera of Fossil Mollusca in the St. Cassian and Hallstatt Beds.

Common to Older Rocks.	Characteristic Triassic Genera.	Common to Newer Rocks.
Cyrtoceras.	Ceratites.	Ammonites.
Orthoceras.	Scoliostoma (or *Cochlearia*).	*Belemnites.
Goniatites.	Naticella.	*Nerinæa.
*Loxonema.	Platystoma.	Opis.
*Holopella.	Isoarca.	Cardita.
Murchisonia.	Pleurophorus.	Trigonia.
Euomphalus.	Myophoria.	Myoconchus.
Porcellia.	Monotis.	Ostrea. 1 sp
*Megalodon.	Koninckia.	Plicatula.
Cyrtia.		Thecidium.

The genera marked by an asterisk are given on the authority of Mr. Suess, the rest on that of Mr. Woodward from fossils of the St. Cassian rocks in the British Museum.

The first column marks the last appearance of several genera which are characteristic of Paleozoic strata. The second shows those genera which are characteristic of the Upper Trias, either as peculiar to it or as reaching their maximum of development at this era. The third column marks the first appearance of genera destined to become more abundant in later ages.

As the Orthoceras had never been met with in the marine Muschelkalk, much surprise was naturally felt at first when 7 or 8 species of the genus were detected in the Hallstatt beds. Among them are some of large dimensions, associated with large Ammonites with foliated lobes, a form never seen before so low in the series, while the orthoceras had never been seen so high; although the latter genus has since been met with in the Adnet, or Lower Lias strata of Austria. We can now no longer doubt that, should we hereafter have an opportunity of studying an equally rich marine fauna of the age of the Bunter sandstone or Lower Trias, the great discordance between Paleozoic and Neozoic forms would almost disappear, and the distance in time between the Permian and Triassic eras would be very much lessened in the estimate of every geologist.

EVIDENCE OF PHANEROGAMOUS PLANTS (NOT GYMNOSPERMS) IN THE COAL FORMATION (p. 374.).

It has been questioned whether hitherto the botanist has obtained from strata older than the Wealden a single well-determined specimen of any flowering plants except Gymnosperms such as Conifers

and Cycads. Hence some imagine that the most highly organised structures of the vegetable kingdom were first created or developed in geological periods comparatively modern, although the antholite of the coal (of which a figure is given at p. 374.) was classed by Lindley, so long ago as 1835, as allied to the Bromeliaceæ. Mr. Charles Bunbury called my attention lately to an antholite in his collection from the Newcastle coal-field, which he compared to Antholyza, an Irideous genus, and on which Dr. Hooker, to whom I have shown it, has sent me the following remarks.

"Kew, Feb. 18. 1857.

"After a careful examination of the beautiful specimen of *Antholithes Pitcairniæ* which you have placed in my hands, I have no hesitation in withdrawing the opinion which I formerly expressed to you (Manual, 5th ed., p. 374.) of the possible coniferous relation of the genus *Antholithes.* All the specimens I had previously examined were very imperfect, and suggested to me the possibility of the so-called flowers being tufts of young leaves like those of the larch. In the specimen now before me, these organs are far more perfect, and confirm (as positively as such materials can) Lindley's idea that *Antholithes* is the spike of a very highly-organised flowering plant in full flower. The specimen, as you are aware, presents no structure, it is an impression, and therefore I can only judge of its possible affinities from appearances. Now, there is nothing whatever known amongst Cryptogamic plants having the most remote resemblance to this *Antholithes*, nor amongst Gymnospermous Phœnogams, but there are, both amongst Monocotyledons and Dicotyledons, genera to which it may plausibly be compared. I allude in the former class to genera of *Bromeliaceæ*, *Scitamineæ*, and *Orchideæ;* in the latter to *Labiatæ*, *Lobeliaceæ*, and some others. Upon the whole, the resemblance is strongest to *Bromeliaceæ*, amongst which the genus *Pitcairnia* is ranked, and which suggested the specific name to Lindley."

Another antholite, apparently of a different species, found by Mr. Prestwich in the coal strata of Coalbrook Dale, and described by Mr. Morris under the name of *Antholites anomalus*, is figured in the Transactions of the Geological Society of London (2nd ser., vol. 5., pl. xxxviii., fig. 5.). It affords additional evidence that the evolution of the floral organs is essentially similar to that of ordinary flowering plants, and quite unlike anything in the Gynaspermous or Cryptogamous classes.

Silurian and Cambrian Rocks, and M. Barrande's Theory of Colonies.

Since I alluded in the text (p. 445.) to M. Barrande's discoveries in Bohemia, in reference to the Paleozoic rocks, I have enjoyed, during the summer of 1856, the high privilege of visiting in his company the field of his successful labours near Prague, of observing

the order and succession of the rocks as interpreted by him, and of inspecting the vast collections which he has accumulated in the course of more than twenty years. These stores are comparable in number and importance rather to the results of a Government survey than to the acquisitions of a private individual. More than 1500 species of fossil invertebrata, previously unknown, with the exception of a few of the Brachiopoda, and all belonging to strata older than the Devonian, have rewarded his skilful search.

M. Barrande has shown, in a recent treatise, that the fauna called by him primordial, a fauna contemporaneous in date with the Cambrian rocks of Great Britain, was also coeval with the fossils of the Alum Schists, and limestones of Sweden, so well described by M. Angelin. In both countries, this fauna, the most ancient yet known, consists almost exclusively of trilobites, scarce any progress having yet been made in bringing to light any mollusca and echinoderms of the same period. Enough, however, has been done to show that distinct natural history provinces existed at those very remote times in Scandinavia, Bohemia, England, and the United States.

Of Trilobites, 27 species have been found in Bohemia in these "primordial" beds, 71 in Scandinavia, 12 in America, and 10 in England, all referable to the same genera, but not one in a hundred of the species being common to the different areas. The doctrine of the universality of a primeval fauna, once so popular, is thus completely and for ever overthrown. If it still lingers in the minds of some paleontologists, it is probably because of the wide range of certain plants of the carboniferous era. But besides that, every day demonstrates this case to be exceptional; it has also become more and more evident that the apparent anomaly is caused partly by the predominance in that ancient flora of ferns and Lycopodiaceæ, orders of which the living species are diffused over as wide a space, and partly by the abundance of plants like the Sigillariæ, of which there are no living analogues. There is no proof that the coniferæ of the carboniferous era had a more extensive range than the living species of the same class.

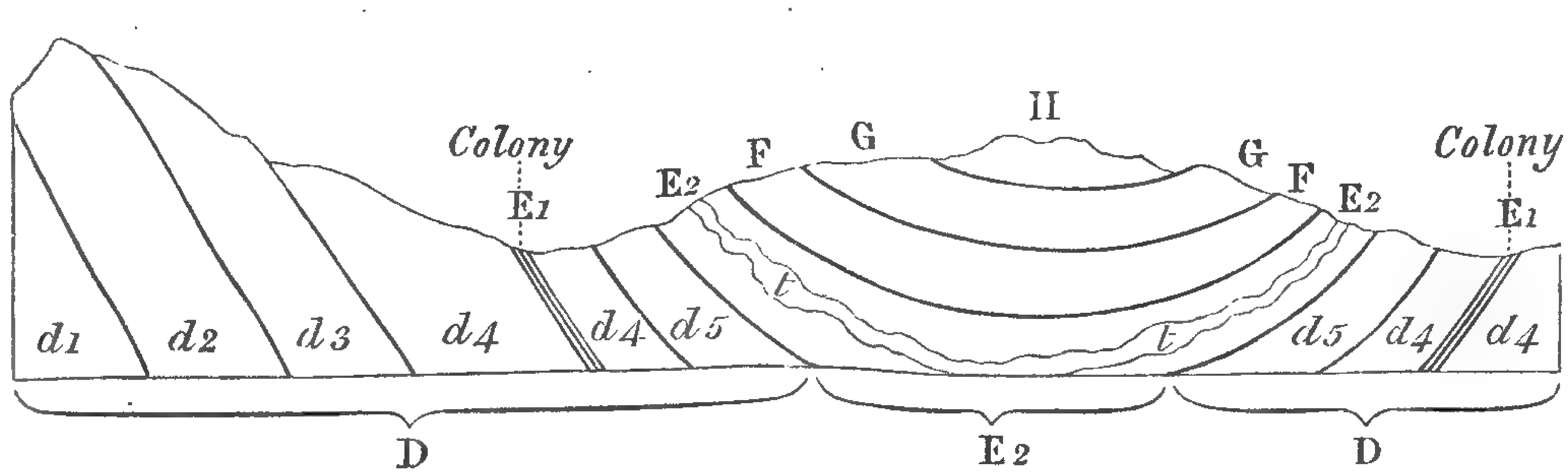
Not only in the earliest known paleozoic epoch has M. Barrande now shown that distinct assemblages of species inhabited separate regions, but also that the same law prevailed in as marked a degree during the times of his second and third faunas, or when rocks of the age of the Lower and Upper Silurian of England were formed. At these periods, not only peculiar species of Crustaceans, but Cephalopods also, and other mollusks, as well as corals, flourished; one set in Bohemia, another in Scandinavia, and others in the several great regions before enumerated, in a word, wherever these ancient strata have been carefully studied.

But if separate portions of the earth have at every former era been simultaneously peopled by distinct sets of marine species, owing to variations in climate, in the depth of the sea, the mineral nature of its bottom, or by reason of the position of continents and the larger islands, and many other conditions in the organic and inorganic

worlds, there must at every former period have been points where distinct zoological provinces were parted from each other by abrupt and narrow barriers, resembling the Isthmus of Suez or the Isthmus of Panama. It is well known that a distinct marine fauna now prevails on each side of those narrow belts of land, and it is evident that a slight subsidence of the earth's crust, to the amount of only a few hundred feet, could cause one host of species to invade the territory of another; and it might, therefore, have naturally been asked, whether there are any signs of such invasions having been effected during those reiterated upheavals and subsidences to which geology bears testimony. M. Barrande has furnished us with a distinct and satisfactory answer to this question, for he has detected near the upper limits of the Lower Silurian strata of Bohemia (in his *étage D.*) an intercalated and lenticular-shaped mass of fossiliferous rock, containing organic remains, almost all of them specifically identical with fossils found in the overlying Upper Silurian deposits. To this intrusive fauna he has given the name of a colony, a name somewhat ambiguous, perhaps, yet which faithfully expresses one part of his theory, namely, that we have here an exemplification of a distinct fauna, nearly allied to his third fauna E, or the Upper Silurian, which during the deposition of the strata D, obtained for a time a settlement within the Bohemian area, and was afterwards expelled, to reappear, after a long lapse of ages, under nearly the same aspect. The following is a copy of the section by which M. Barrande illustrates this doctrine of colonies, which, so far as relates to the geological sequence and position of the rocks, I have verified on the spot. It

Section through the basin-shaped Silurian Strata of the Centre of Bohemia. — Barrande.

Fig. 7.



D. Lower Silurian, with fossils of the 2nd fauna of Barrande, coeval with Llandeilo flags of Murchison.
d 1. to *d* 5. Subdivision of the same.
E 1. Colony or intercalated beds, with fossils specifically identical, for the most part, with those of E 2.
E 2., F., G., H. } Subdivisions of the Upper Silurian, with fossils of the 3rd fauna of Barrande.
t. Trap of contemporaneous origin with E 2., and of which some also occur in the colony E 1.

will be seen that the colony styled E by M. Barrande, but which I shall call E 1., occurs in the midst of the strata *d* 4., one of the subdivisions of D 3., so designated by Barrande. The colonial fauna proper to E 1. contains as many as 65 species, five of them peculiar,

or not known elsewhere, two common to the fauna of *d* 4., in which they are intercalated, and the remaining 58 common to the base of Barrande's third or Upper Silurian fauna, which I have designated as E 2.

The late Edward Forbes, when commenting on this doctrine of colonies, observed that if accepted it would materially affect the value of the evidence of organic remains, as determining the age and sequence of geological formations, since the proposition involves the introduction of a group of species that experience has shown normally to belong to a later and distinct formation not merely among and mixed with the fauna of an earlier stage, but amid and separate from that fauna.* Professor Forbes, therefore, while expressing the highest admiration of M. Barrande's talents and labours, questions the accuracy of his geological facts, remarking, "that in a disturbed Silurian country where the strata lie at very high angles, and where there are probably convolutions and contortions of the beds, there may be such overturns as would cause the appearance of strata containing newer fossils to lie under and amid those containing older ones." But had my late friend visited the neighbourhood of Prague, he would have learnt that the strata there are not in a state of Alpine confusion, and he would readily have convinced himself that so able an observer as M. Barrande had not been in any way deceived. In fact, the order of super-position is not obscure, and besides, there is one spot in the suburbs of Prague which I examined, where the intercalated colonial formation E 1. is reduced in thickness to 6 inches, and where nevertheless it is quite distinguishable by its organic contents, although, as we might have anticipated, there occurs here a slight blending of the distinct faunas, two species of *d* 4. being associated with a great number of the characteristic fossils of E 1.

How, then, are we to explain the phenomena? The facts themselves seem to have been very generally misunderstood, partly, perhaps, in consequence of the use of the term "colony." M. Barrande has been treated very much as an antiquary would be should he pretend to have found monumental evidence of an Anglo-Saxon colony established on Roman ground in the days of the Emperor Justinian; whereas there is really no such anachronism in the paleontological facts, as exhibited in Bohemia, and as described by the author of the "Colonial" theory. He simply tells us, that out of 63 species, 5 are peculiar to the colony where it is in its full strength, — in other words, there is a difference between the species of E 1. and of E 2., amounting to about 8 or 9 per cent., indicating a change of no less than one-twelfth of the whole fauna in the interval between E 1. and E 2., to say nothing of such discordance as would certainly be found to exist when the rarity of particular species of the colonial period came to be contrasted with their abundance in E 2., and *vice versâ.*

Before a geologist is entitled to regard this case as abnormal, or not in harmony with the laws known to have governed the fluctua-

* Quart. Geol. Journ. 1854, vol. x. p. 34.

tions of the organic world in byegone ages, he must show that the fauna called D underwent much greater alterations than E in the interval of time between the colony E 1. and the era called E 2.,— in other words, he ought to show that more than a twelfth of the species of D died out, and more than 8 or 9 in 100 of new species came in, in the interval separating *d* 4. and *d* 5. Now, so far as I have learnt from M. Barrande, no details have as yet been ascertained respecting the fossils of these two subdivisions sufficiently minute to entitle any one to infer that the rate of fluctuation of the two faunas, within the period alluded to, was very unequal. In the course of the interval between E 1. and E 2., strata of micaceous shale and sandstone of the system D, more than 3,000 feet thick, were deposited; and during the accumulation of this immense mass of rock some species disappeared, while many survived and are common to *d* 4. and *d* 5.; other fossils being peculiar to each of those subdivisions respectively.

Trap rocks accompany the "Colonial beds" E 1., and are decidedly of contemporaneous origin. Occasionally an orthoceras may be seen involved in the greenstone, while pebbles and angular fragments of trap are intermixed with the fossils of the colony.

Again, there are other intrusions of similar igneous rocks at the base of E 2., and M. Barrande with good reason appeals to these volcanic appearances as lending support to his hypothesis of former changes of level, by which a barrier of land may have been lowered for a time so as to allow currents of salt-water flowing from the north-east to introduce the fauna E 1. into the region previously occupied by D; and a recurrence, he remarks, of similar oscillations may afterwards have caused the retreat of the colonists, as well as their subsequent return and the re-establishment of the fauna E 2. in Bohemia. Warm currents, like the Gulf Stream, pouring into a colder sea, might carry with them a whole assemblage of species fitted for a more elevated temperature, and capable of superseding the natives of a colder sea, while colder currents invading a warmer sea might give rise to analogous phenomena. In each case along the edges of the space thus colonised, some members of the old native fauna might maintain their ground against the new comers; and this may explain why, when the deposit E 1. thins out to a few inches, some species of D are intermingled with those of E 1.

It may be useful to add that in E 2. (a calcareous formation only 500 feet in thickness), no less than 900 species of fossil invertebrata have been found by M. Barrande. This set of strata passes upwards into F, and this again into G, and G into H, each having, at the point of contact, so many species in common, that M. Barrande has thought it necessary to regard the whole as one system; yet such is the aggregate result of continual changes, that when the two extremes of the series are contrasted, there is only 1 per cent. common to E 2. and H.

* Quart. Geol. Journ. vol. xii p. 204. 1856.

Many important conclusions will follow if we admit the accuracy of the facts and reasonings above set forth. M. Barrande has himself remarked, that before his discoveries were made, a geologist, finding in some part of Europe to the North-east of Prague, rocks characterised by the fossils of E 1., would certainly have regarded them as Upper Silurian, instead of assigning them to their true era, viz., that of D, or the Lower Silurian. On the other hand, if the fauna D, after it was locally exterminated in the region of Prague, still continued to flourish elsewhere under a slightly modified form which might, in accordance with M. Barrande's nomenclature, be styled *d* 6.—such a fauna might certainly be mistaken by the best geologists for one of Lower Silurian date, although, in truth, of later origin.

The imagination may well take alarm at the confusion which we may expect to encounter in settling sundry questions of Geological chronology when we have to deal with ancient deposits found on the frontiers of distinct Natural History provinces. But it is consolatory to reflect that all this ambiguity will arise out of the strict agreement prevailing between the present and ancient condition of the globe, and the laws governing the changes of its surface, whether they be those of the animate or inanimate world. So long as we feel sure that in existing nature we have a key for interpreting the mysteries of the past, we need never despair, whereas had the causes acting in the remoter ages differed either in kind or degree from those now operating, our science must for ever have continued one of mere conjecture and ingenious speculation.

ANTIQUITY OF FOSSIL BIRDS (p. 460.).

Since the table printed at p. 460. was compiled (in 1854), the records of this great class of Vertebrata can be carried back somewhat farther in time, or one step lower down in the Tertiary series. Early in 1855 the tibia and femur of a large bird equalling at least the ostrich in size were found at Meudon near Paris, at the base of the Plastic clay. This bird, to which the name of *Gastornis Parisiensis* has been assigned, appears, from the Memoirs of MM. Hébert, Lartet, and Owen, to belong to an extinct genus. Professor Owen refers it to the class of wading land birds rather than to an aquatic species.

That a formation so much explored for economical purposes as the Argile Plastique around Paris, and the clays and sands of corresponding age near London should never have afforded any vestige of a feathered biped previously to the year 1855, shows what diligent search and what skill in osteological interpretation are required before the existence of birds of remote ages can be proved by more decisive evidence than their supposed foot-prints.

ERRATA IN FIFTH EDITION.

Page 25., line 2. from bottom (fig. 20.) for "Gaillonella" read "Gallonella."
,, ,, fig. 17. and fig. 18. ditto. ditto.
,, 31., fig. 52., for "London clay" read "Barton clay."
,, 39., line 6. from bottom, for "pores" read "cells."
,, ,, fig. 52., for "Trochus Anglicus" read "Pleurotomaria Anglica."
,, 104., line 6. from bottom, for thirty-three" read "thirty-five."
,, 105., line 11. from bottom, for "Falurien" read "Falunien."
,, 108., third column, line 10. from bottom, for "Etages C. and D." read "Etage D."
,, 125., line 28. and fig. 108., for "Helix plebeium" read "Helix plebeia."
,, 156., line 1., for "*angustidens*" read "*arvernensis.*"
,, 160., line 15. from bottom, for "species" read "spaces."
,, 165., last line, for "Xivi" read "Kiwi."
,, 166., fig. 135. title, for "M. *angustidens*" read "M. *arvernensis.*"
,, 167., fig. 137. title, for "Hippopotamus" read "Hippopotamus Pentlandi. H. v. Meyer."
,, 169., note, line 5. from bottom, for "J. O. Thompson" read "J. V. Thompson."
,, 181., line 14. from bottom, for "flaules" read "flanks."
,, 183., line 11. from bottom, for "posterogenitum" read "posterogenium."
,, 192., line 11., for "newer" read "older."
,, 205., line 18. from bottom, for "mound" read "mould."
,, 207., line 8. from bottom, for "*Macairodus*" read "*Machairodus.*"
,, 211., line 4. from bottom, for "Potomomya" read "Potamomya."
,, 215., fig. 207., for "typhæus" read "typhoeus."
,, 227., line 6. from bottom, for "*Cyrithia*" read "*Cerithia.*"
,, 229., fig. 240. title, for "Schemidelliana" read "Schmidelliana."
,, 238., line 9. from bottom, insert "Etage" before "Danien." "Etage Danien," "Etage Senonien," &c.
,, 246., fig. 254., for "Micrastes" read "Micraster.",
,, ,, ,, for "cor anguinum" read "cor-anguinum."
,, ,, fig. 258., for "B. Fanjasii" read "B. Faujasii."
,, ,, line 2. from bottom, for "Marsupiles" read "Marsupites."
,, 248., fig. 275., right-hand figure is a valve of Ostrea distorta (see p. 295.) inserted here by mistake.
,, 260., fig. 301., for "tella" read "sella."
,, 295., line 15., for "*Chilira*" read "*Chilina.*"
,, 310., note, last line, for "Priomus" read "Prionus."
,, 425., note, line 3., for "Fred. Roemer" read "Fried. A. Roemer."
,, ,, note, for "Dr. Fred. Sandberger" read "Dr. Fridolin Sandberger."
,, 445., line 4. from bottom, for "Vigularia" read "Virgularia."
,, 493., line 7. from bottom, for "1,400" read "14,000."
,, 497., line 2. from bottom, for "corrosive" read "erosive."
,, 498., line 19., for "16" read "46."
,, 502., line 11. from bottom, for "a quarter" read "half or a quarter."
,, 521., line 11. from bottom, for "northern" read "southern."
,, 641., Index, first line (in italics), for "*figures*" read "*figured.*"
,, 644., ,, line 20., for "into lignite" read "lignite into."